Ice-shoved ramparts in Lake Clark NPP and the Kenai Lowland: winter ice expansion vs. wind-driven ice pans during spring breakup

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SWAN Science Conference

Anchorage

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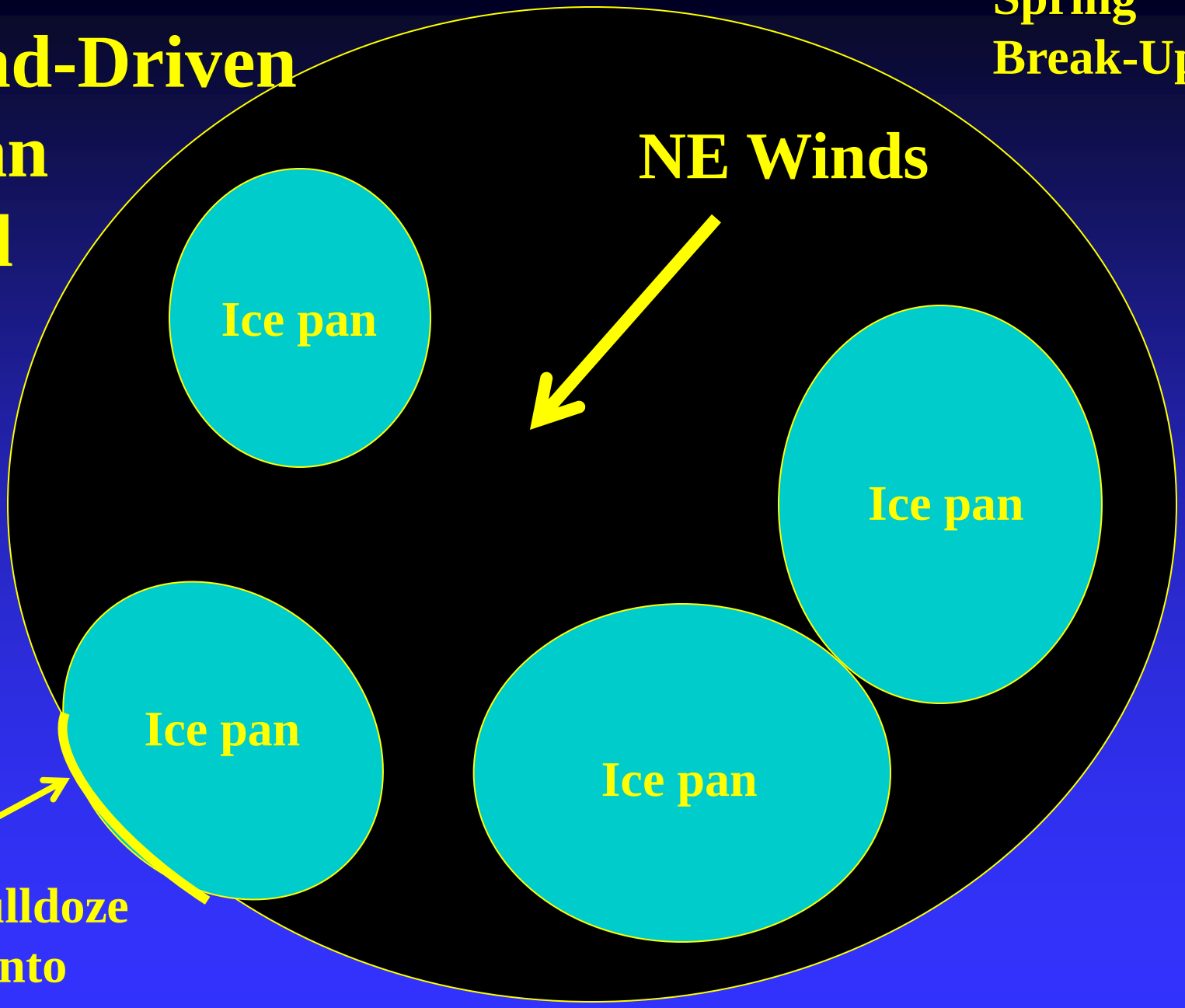
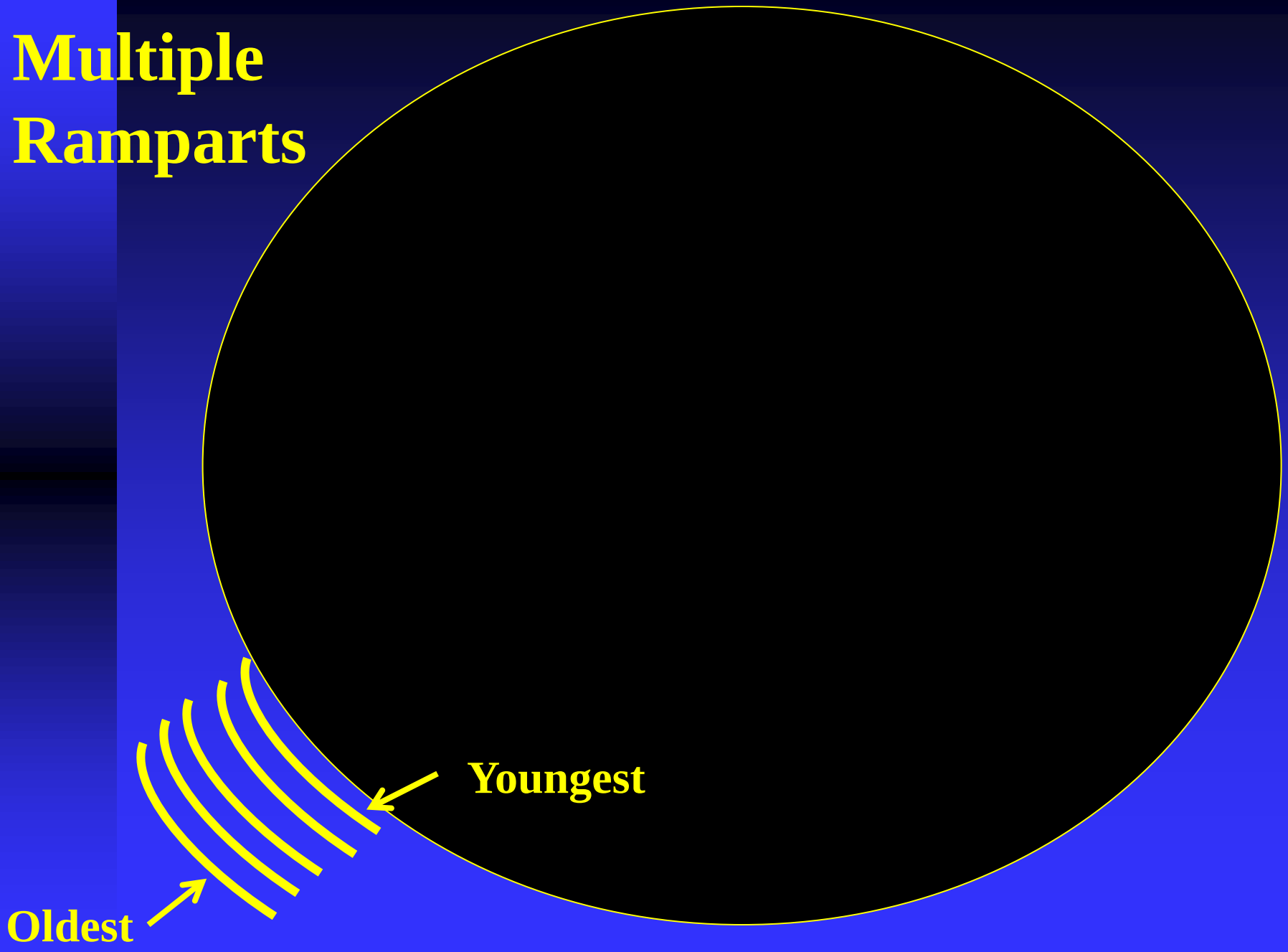
Ice-Shoved Ramparts are berms around lakes pushed up by lake ice

Barabara Lake

I. Wind-Driven Ice Pan Model

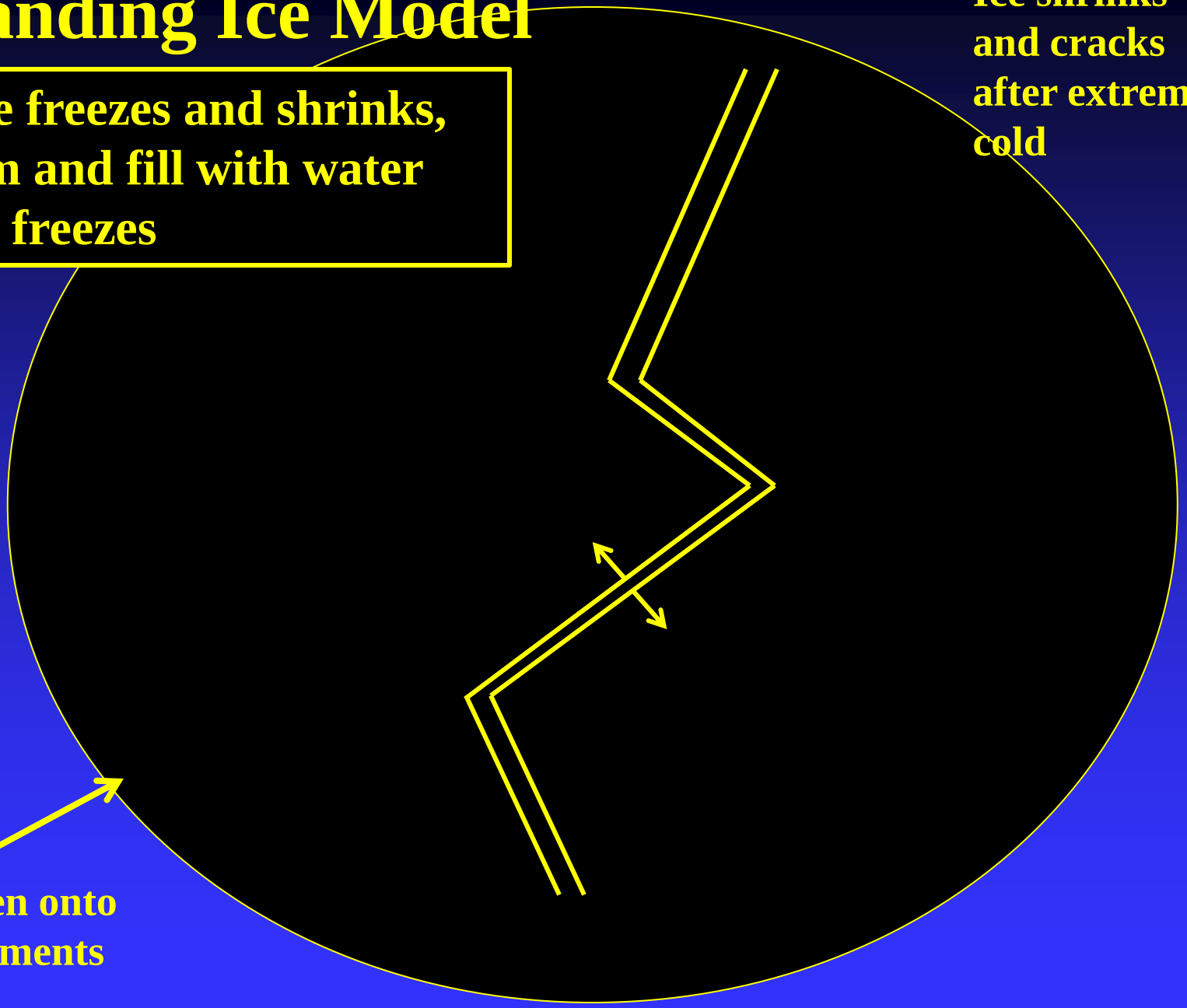


Multiple Ramparts

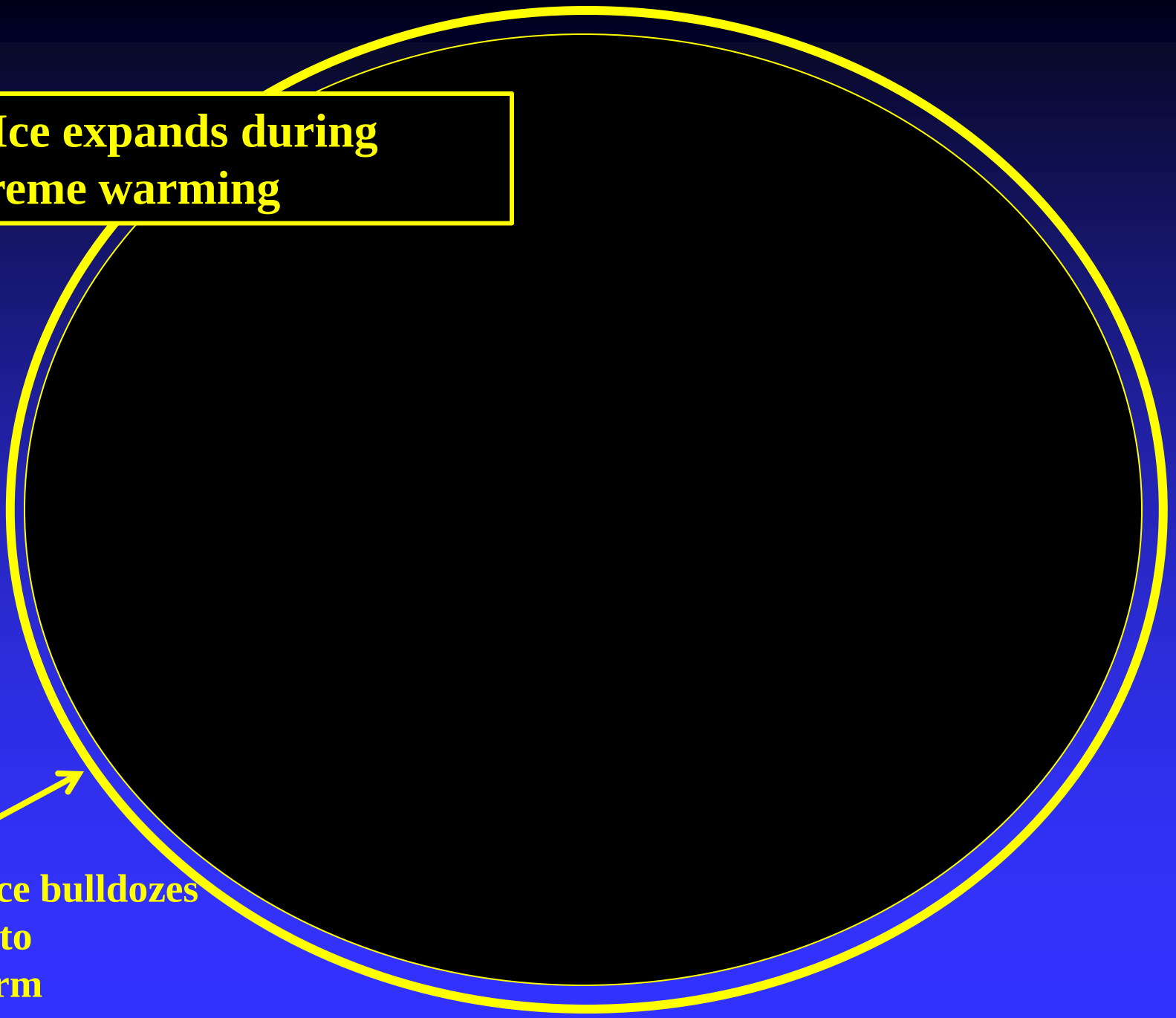


II. Expanding Ice Model

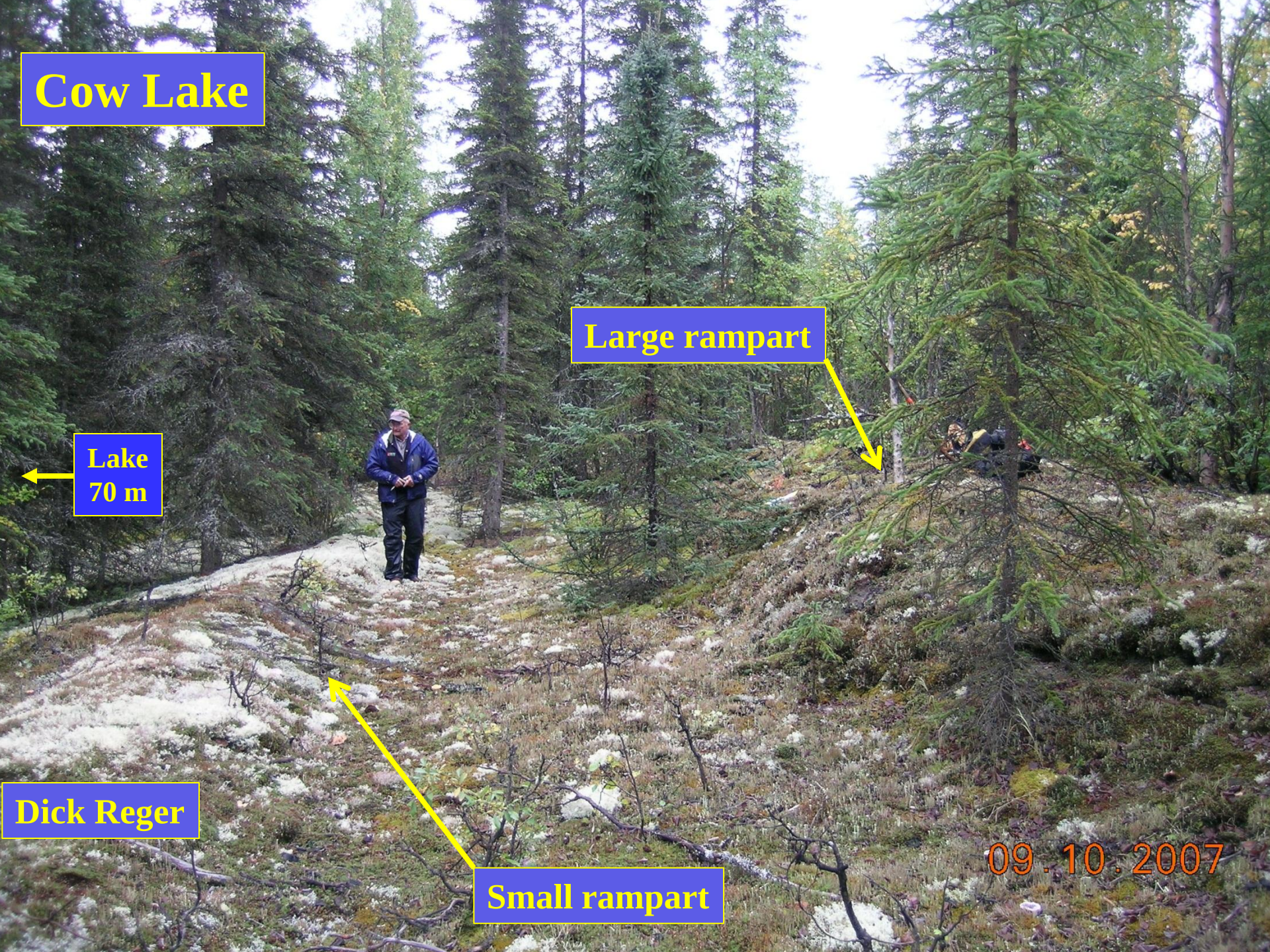
1st Step: Ice freezes and shrinks, cracks form and fill with water which then freezes



2nd Step: Ice expands during rapid extreme warming

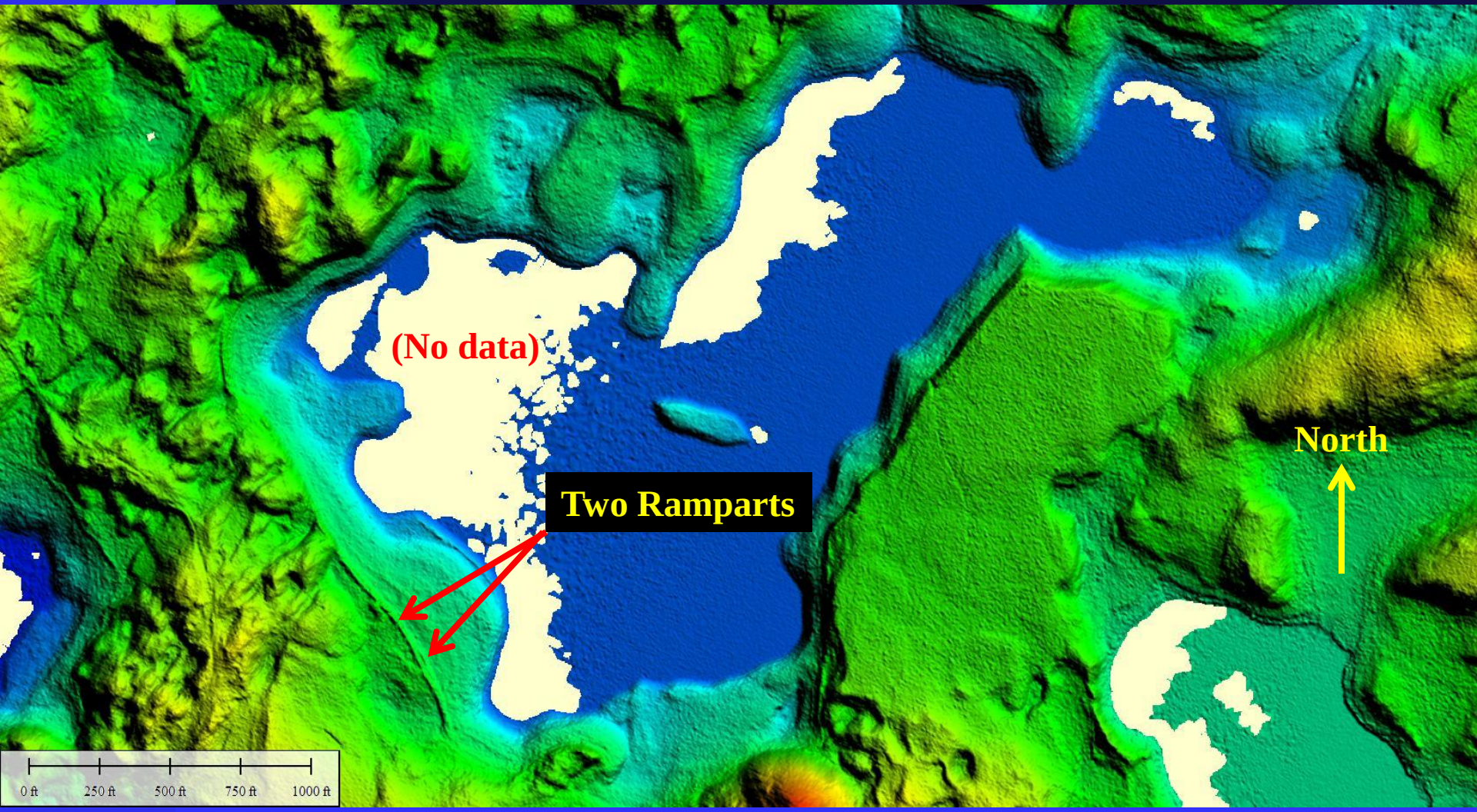


Expanding ice bulldozes sediments into shoreline berm


Cow Lake
Large rampart
Lake
70 m
Dick Reger
Small rampart
09.10.2007

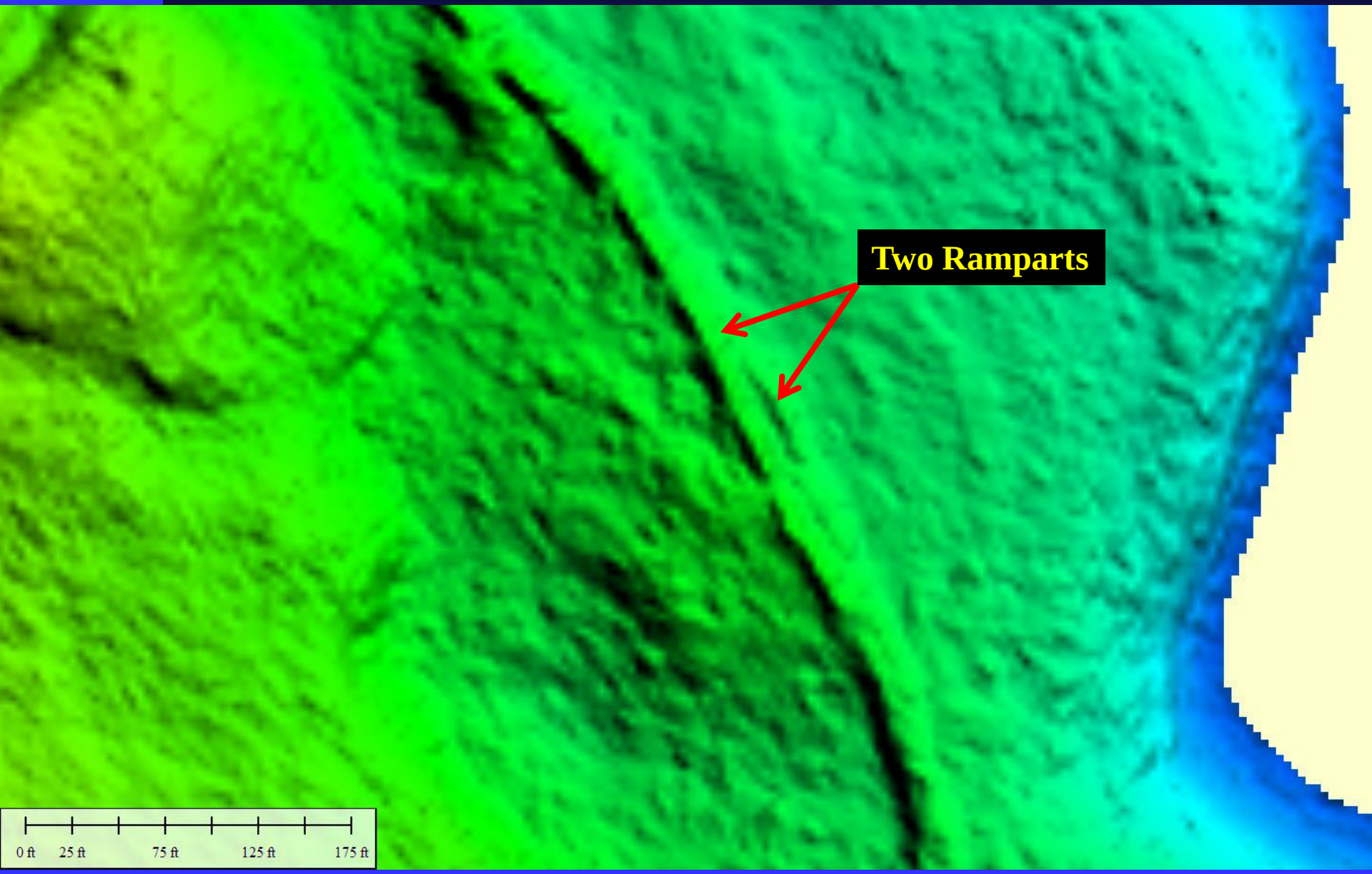
Cow Lake Bare-Earth LiDAR Image

(LiDAR = Light Detection and Range)

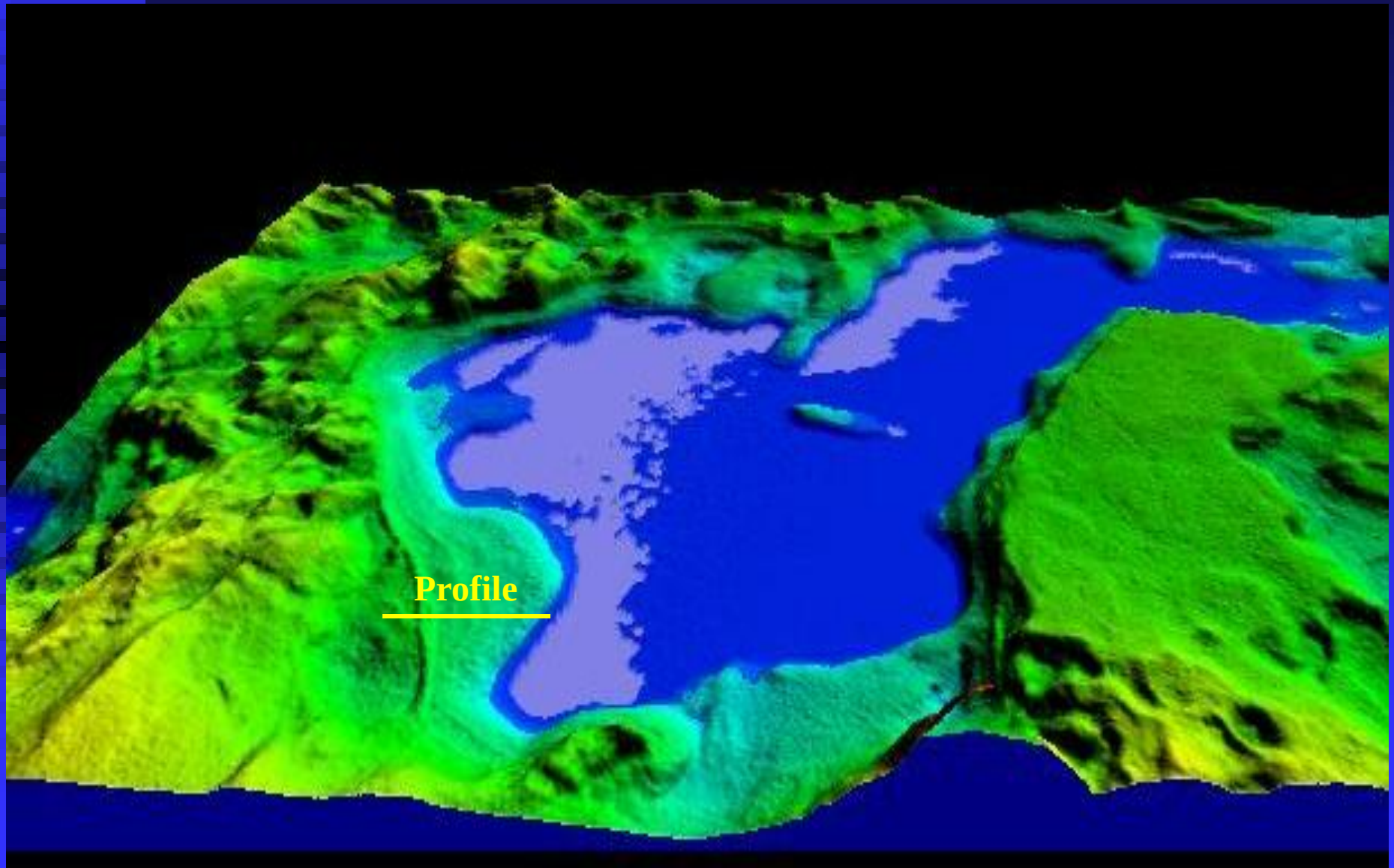


Cow Lake fits the wind-drive ice pan model, with ramparts on the Southwest shore

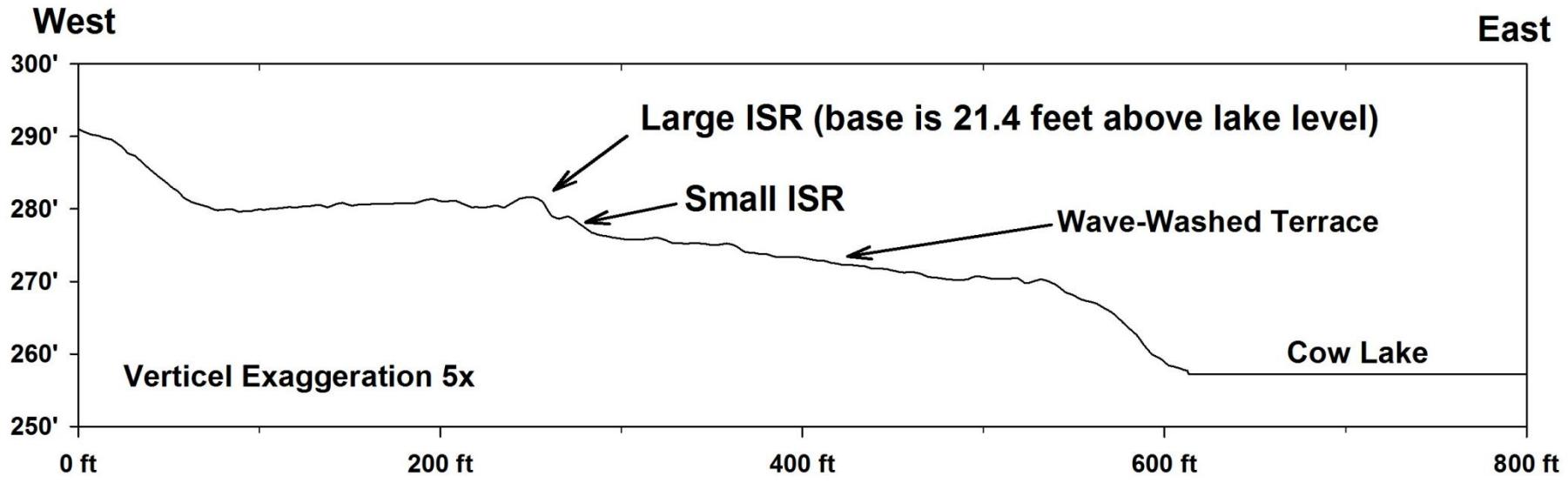
Cow Lake - LiDAR detail



Cow Lake – 3-D LiDAR View from South



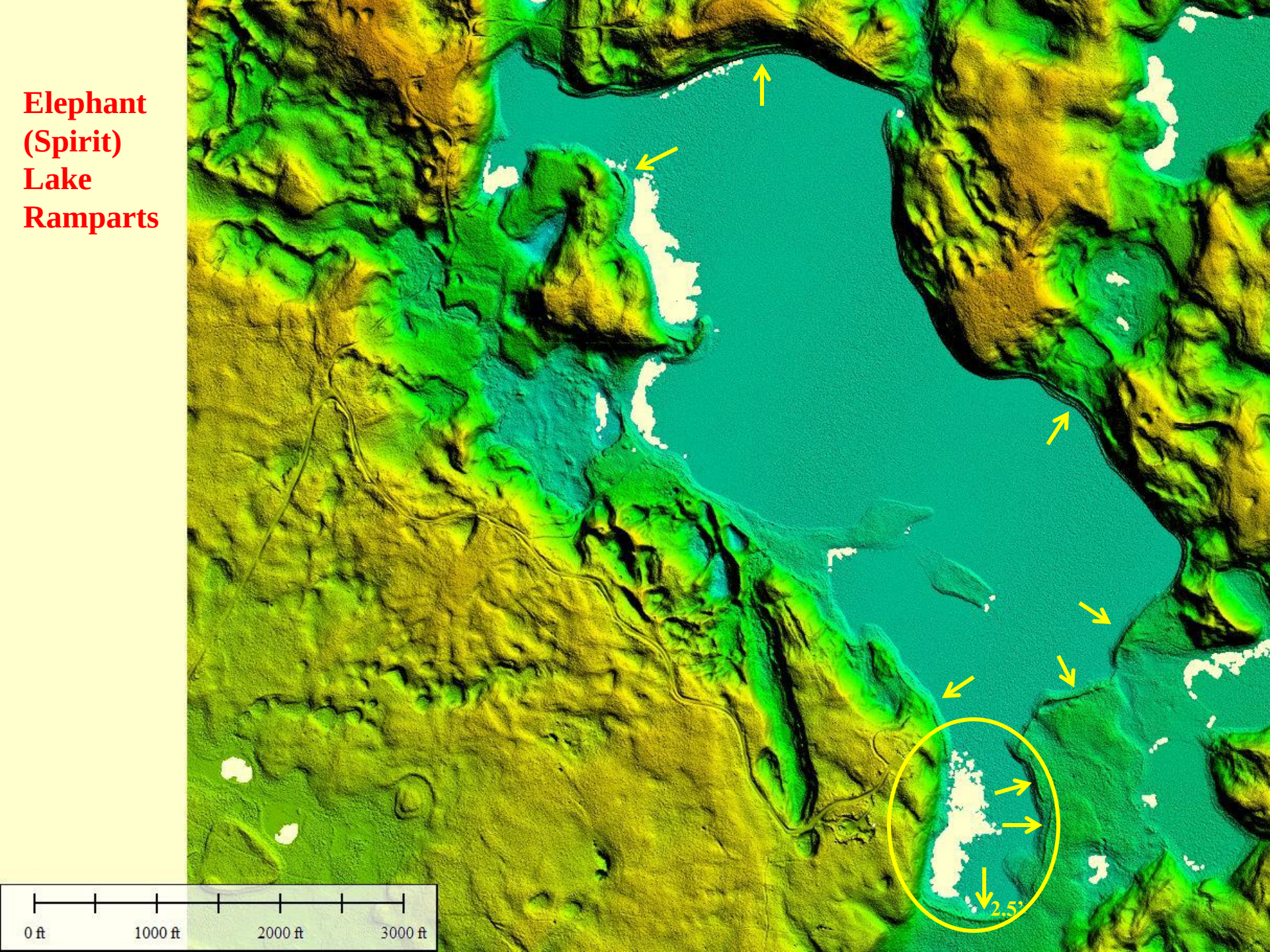
Cow Lake LiDAR Profile



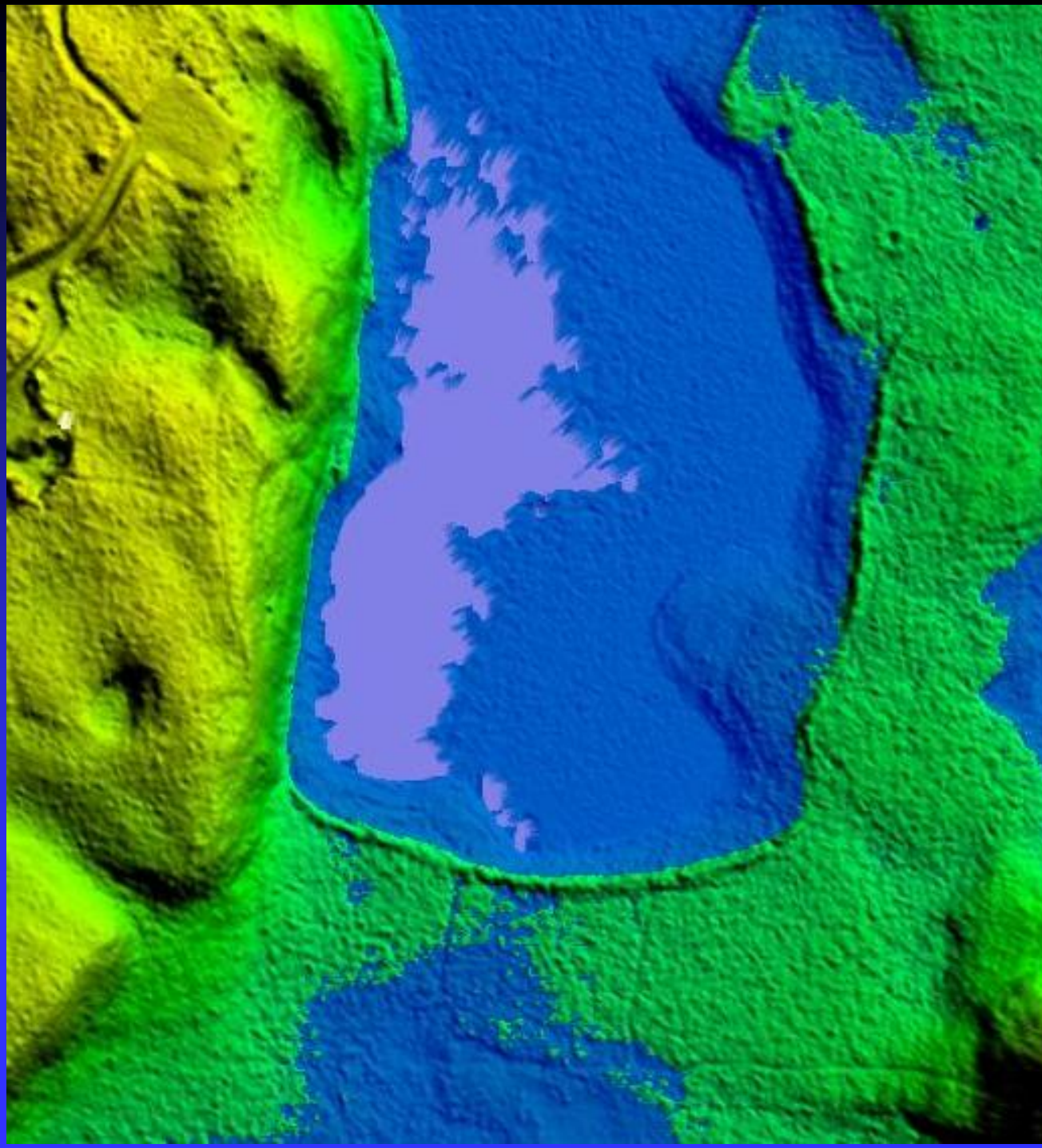
Profile elevation created with Global Mapper software

Elephant (Spirit) Lake Ramparts

Elephant (Spirit) Lake Ramparts



Adding 6 feet of water to present lake level



Elephant (Spirit) Lake

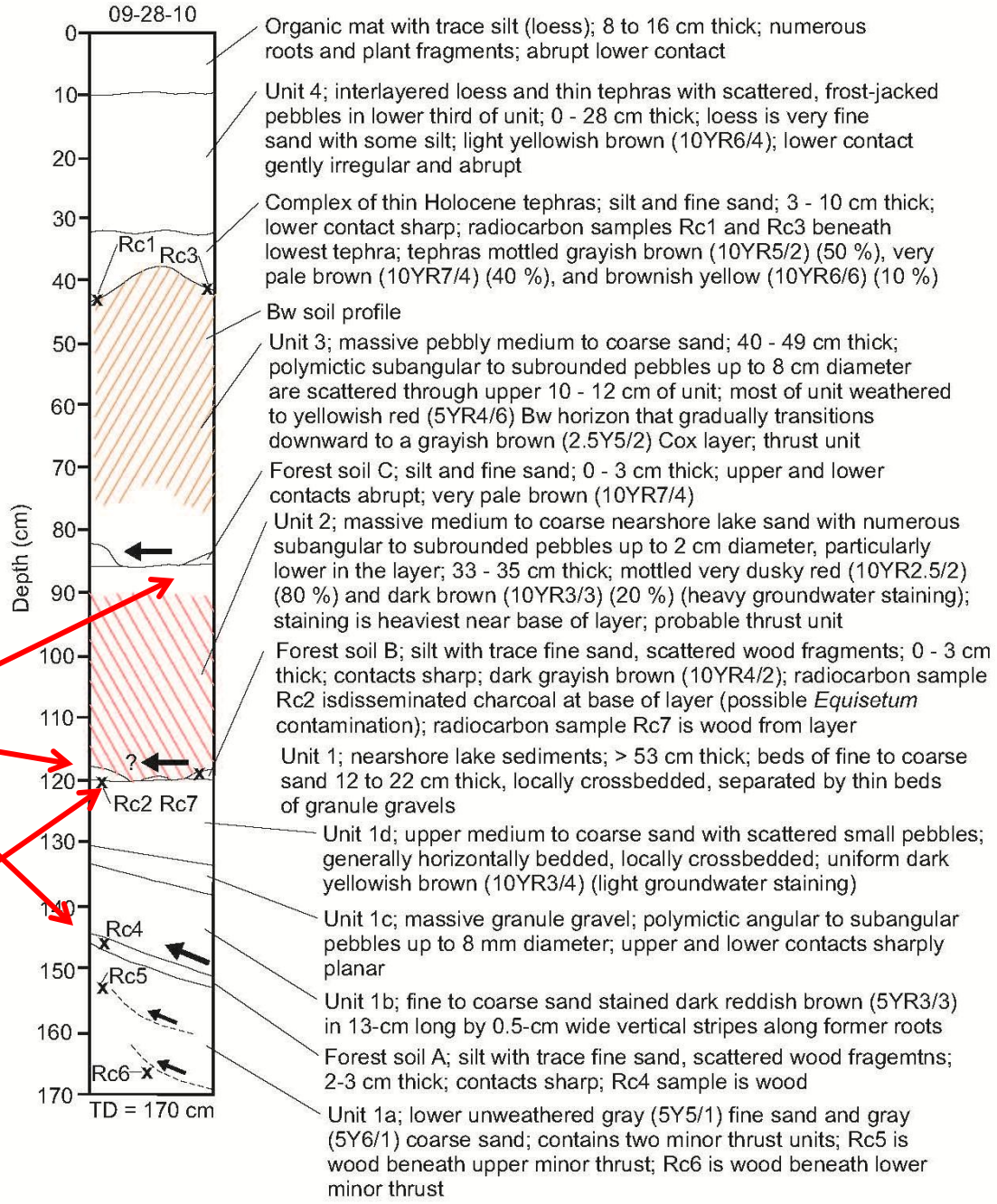
Upper Pollard Lake

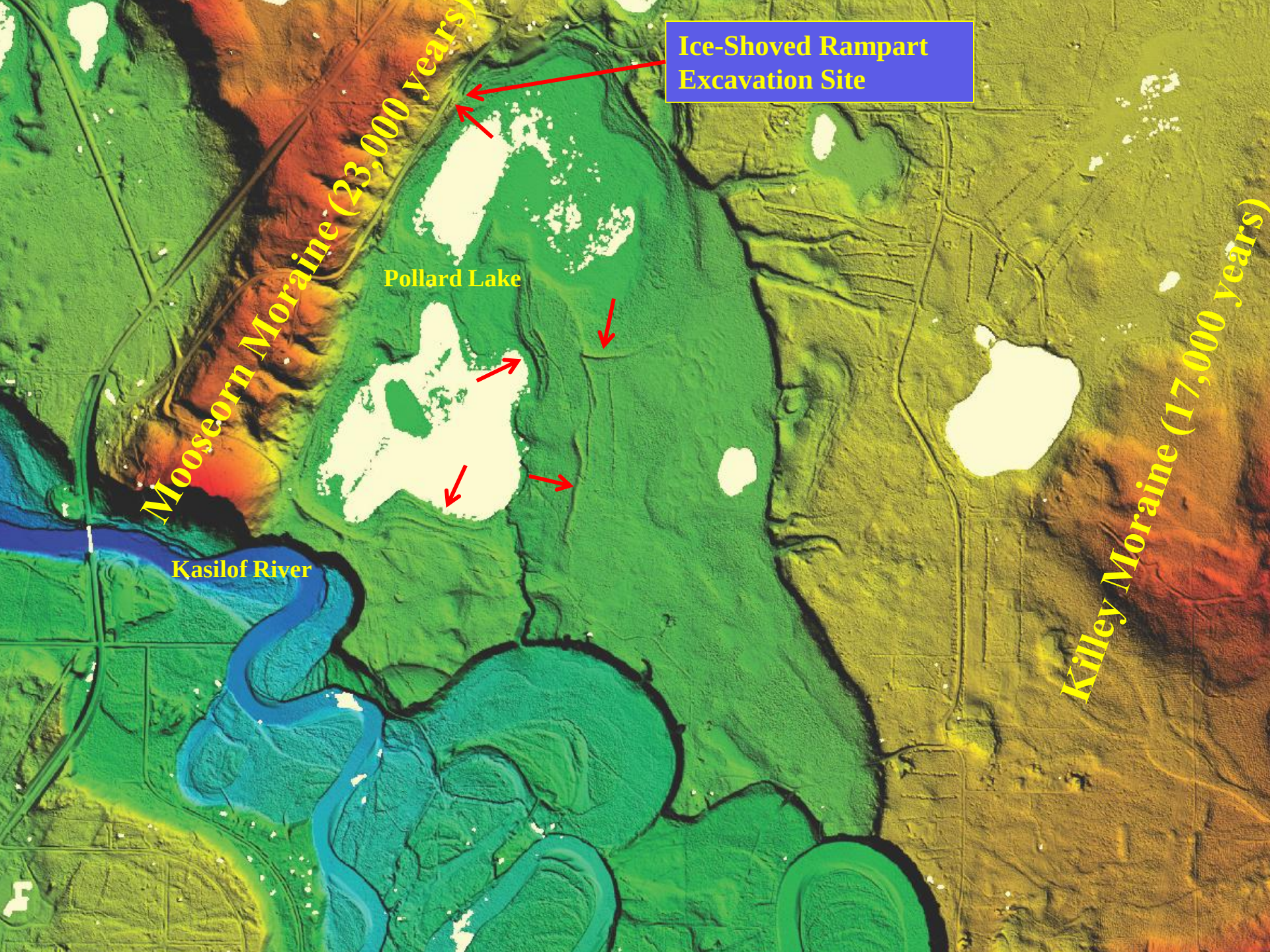
Toby Burke and Dick Reger

Pollard Lake Rampart Soil Profile

Buried Forest Soil Layers

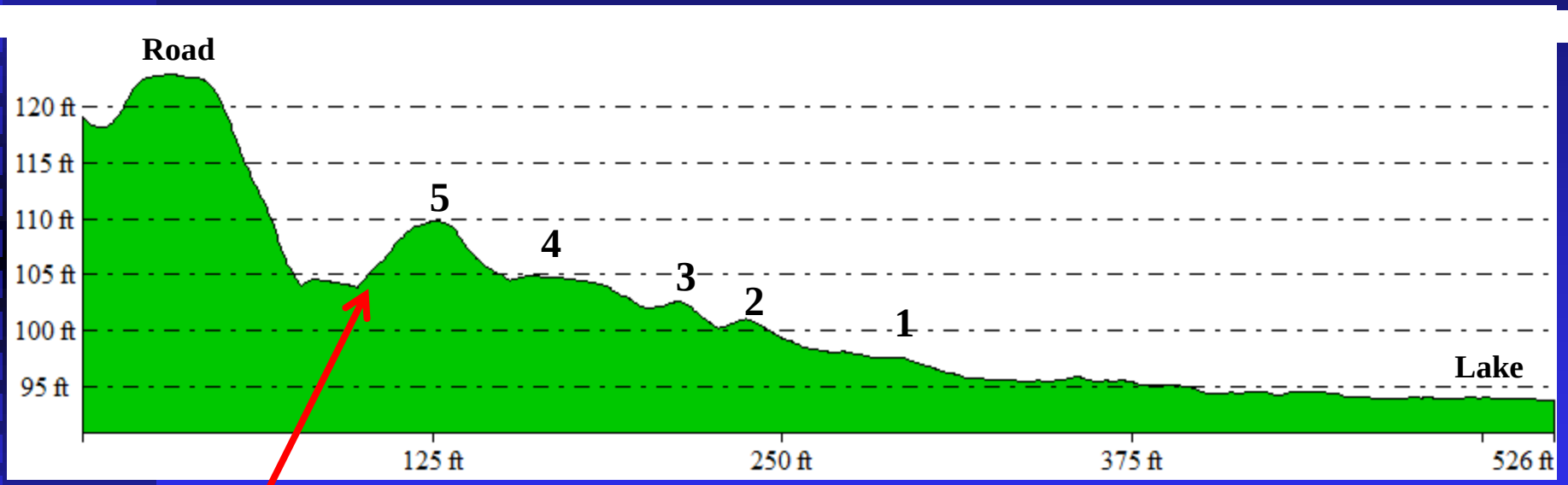
Rc2 - 11,200 cal years BP (minimum age)




Ice-Shoved Rampart
Excavation Site
Pollard Lake
Mooseorn Moraine (23,000 years)
Kasilof River
Killey Moraine (17,000 years)

Upper Pollard Lake Ice-Shoved Ramparts

NW SE

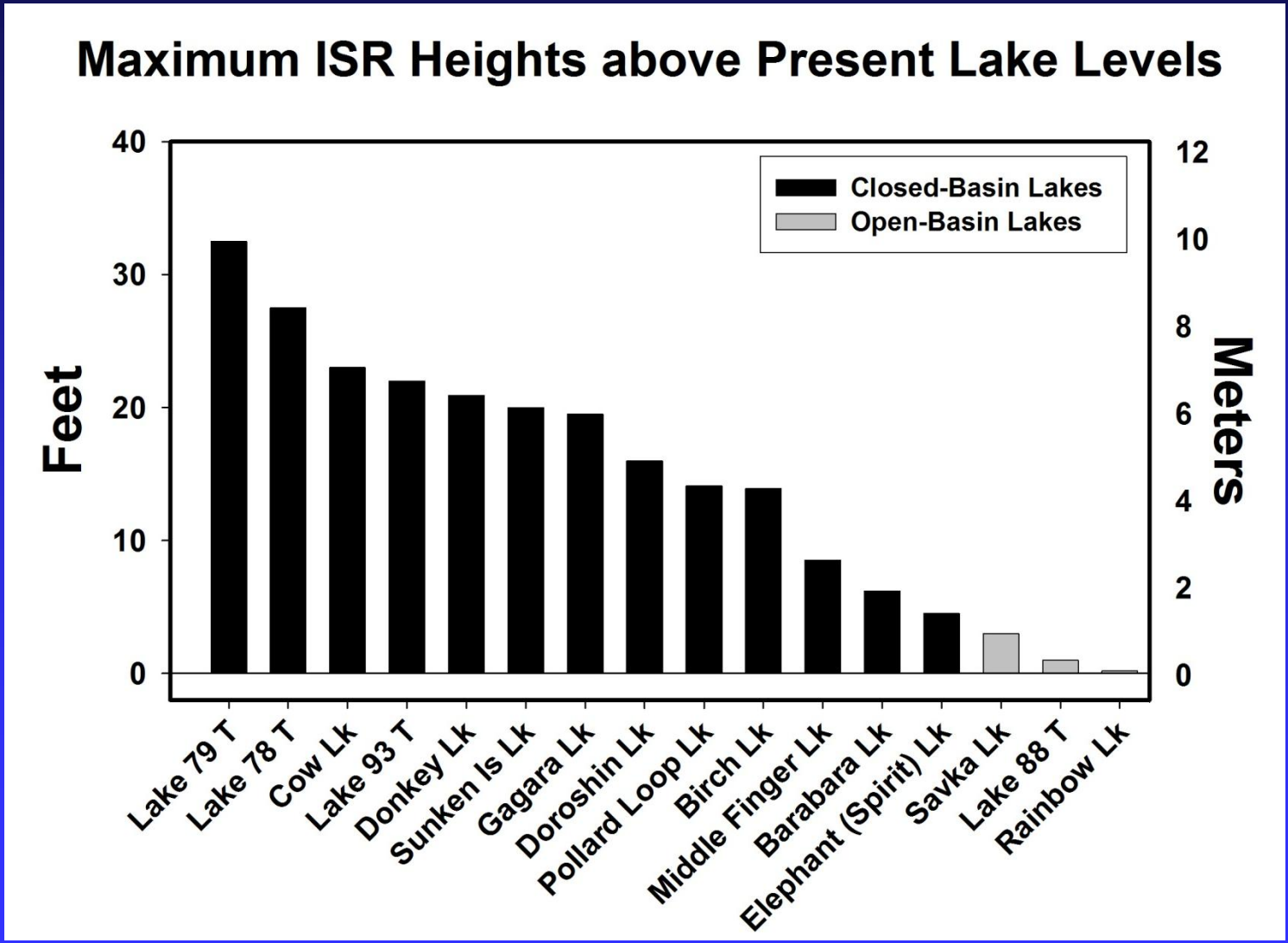


Vertical Exaggeration 3.7x

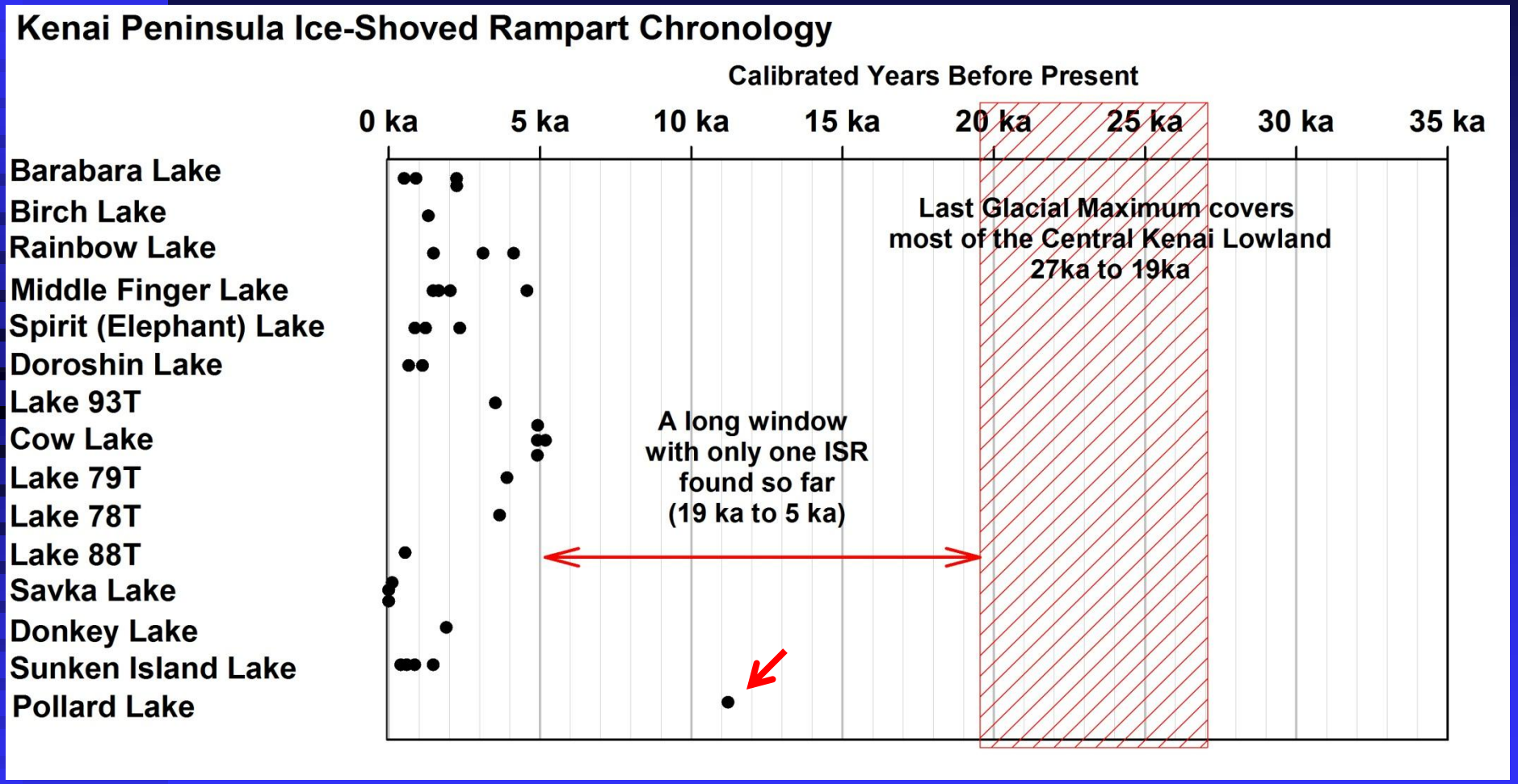
Excavation Site
9/28/10 & 8/30/11

Profile obtained with
Global Mapper software

Many of these ramparts were formed when lakes were much fuller, i.e., a wetter climate

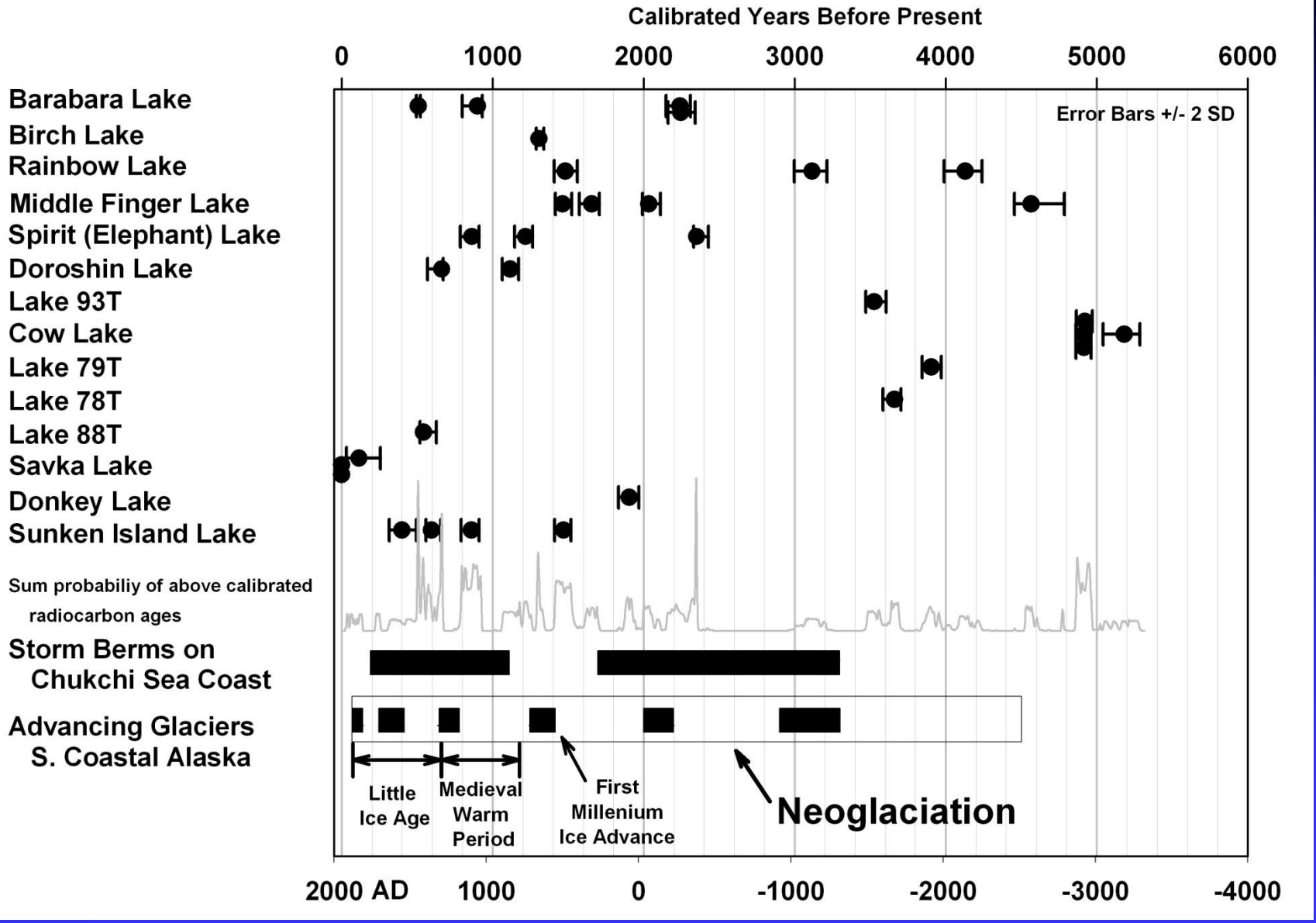


Puzzle: What is different about the climate of the last 5000 years?



Higher lake levels – Yes
Colder winters – Probably
Stronger spring winds - Probably

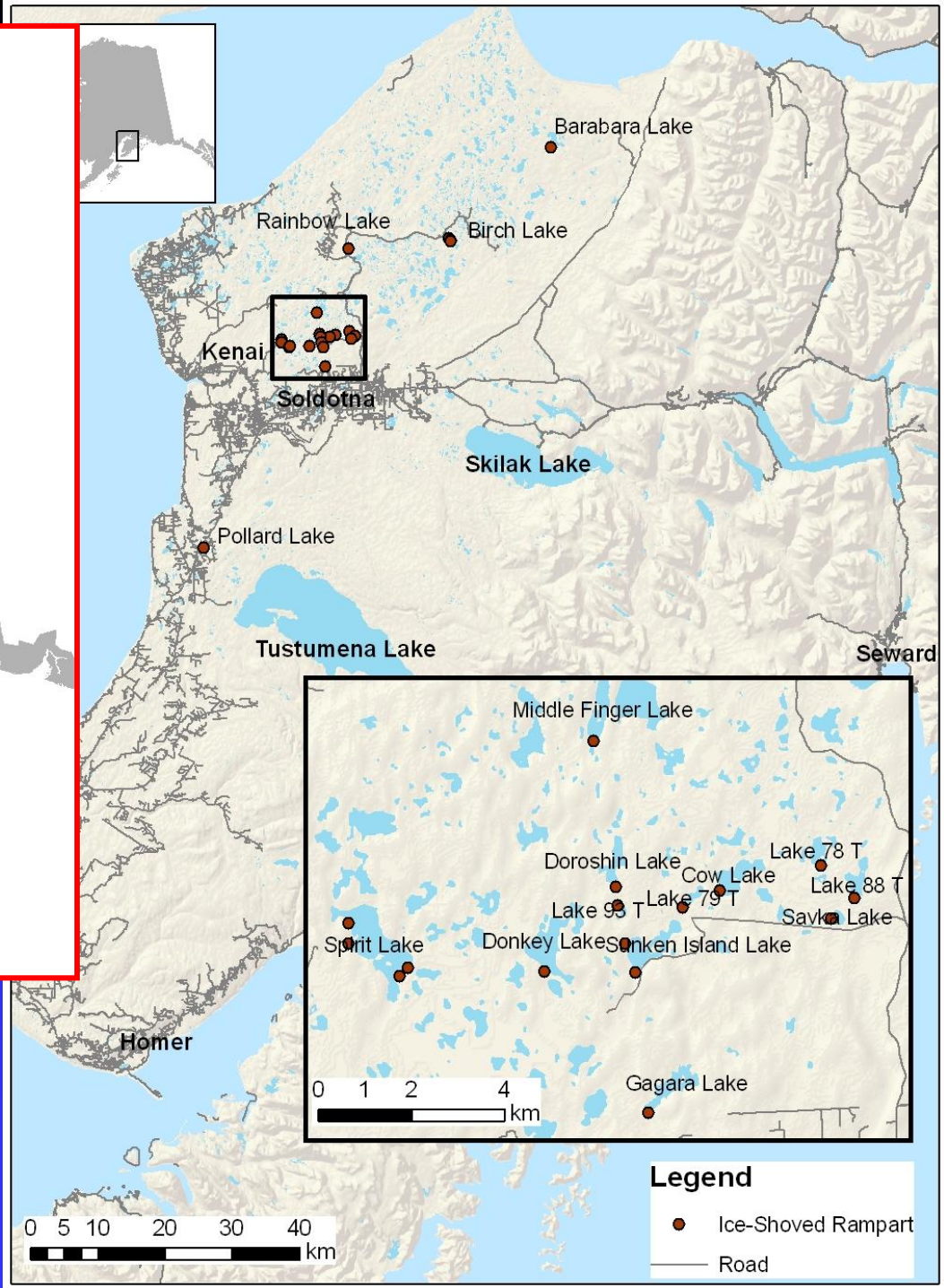
Radiocarbon Dates from Kenai Ice-Shoved Ramparts



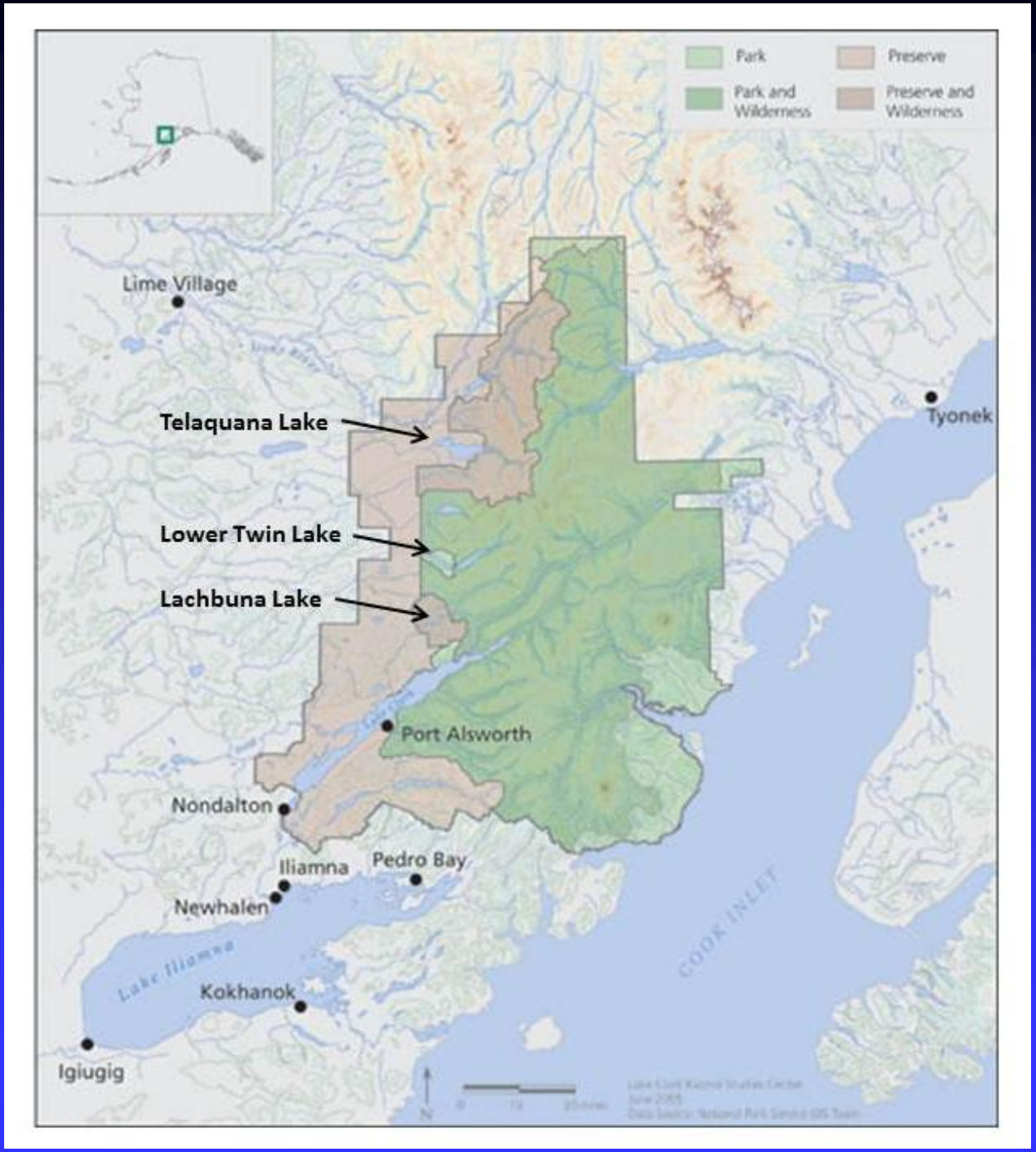
Application of This Study

Accurate information about the climate history of the last 5000 years should provide useful for calibrating General Circulation Models (GCM's) of future climate.

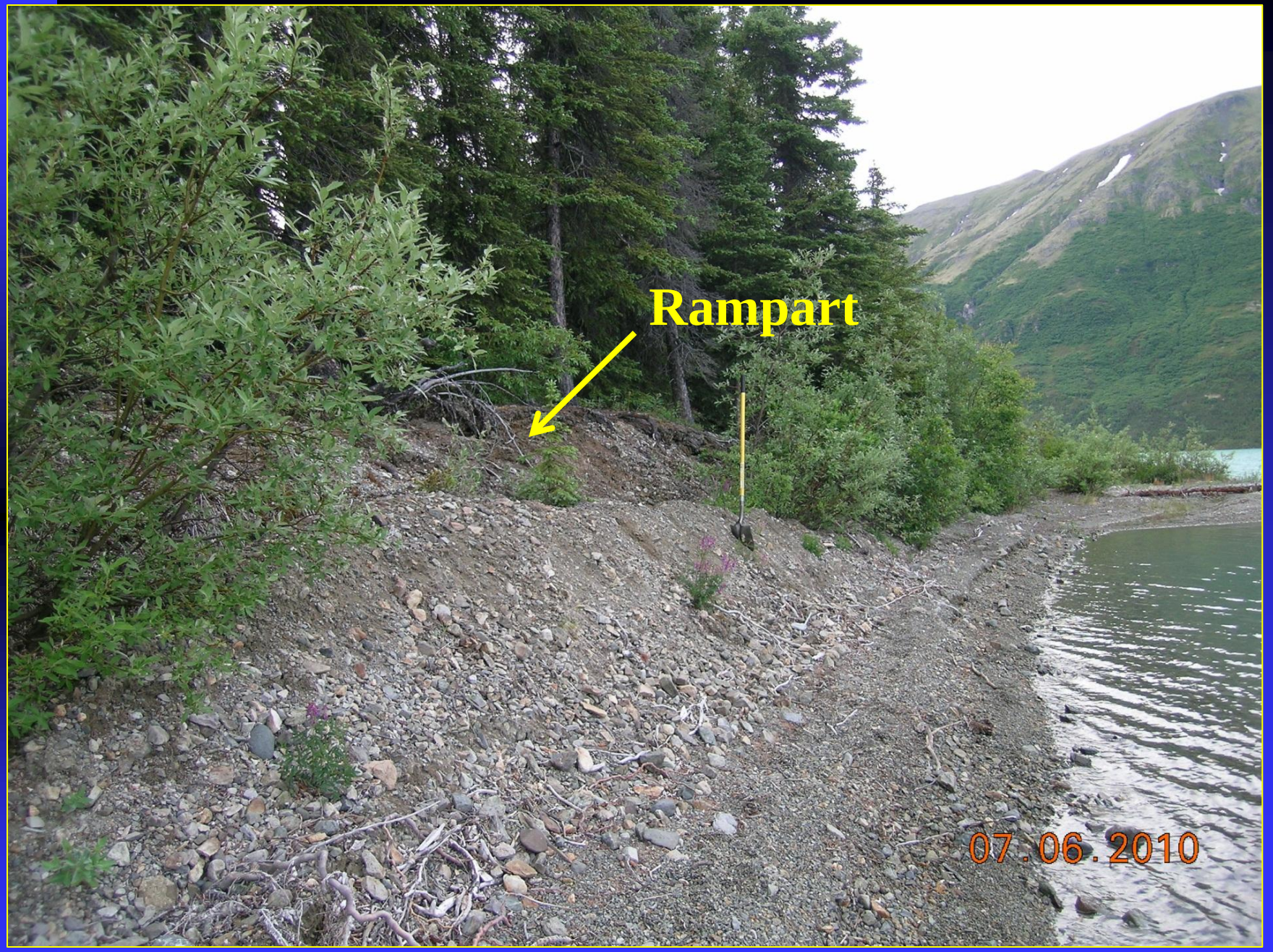

Fairbanks
Birch Lake
Lake George
Tok
Telaquana Lake
Anchorage
Lachbuna Lake
Kenai ISR Sites
Lower Twin Lake
King Salmon


Barabara Lake
Rainbow Lake
Birch Lake
Kenai
Soldotna
Skilak Lake
Pollard Lake
Tustumena Lake
Seward
Middle Finger Lake
Doroshin Lake
Cow Lake
Lake 78 T
Lake 88 T
Lake 79 T
Lake 93 T
Savka Lake
Spirit Lake
Donkey Lake
Sunken Island Lake
Homer
Gagara Lake
0 1 2 4
km
0 5 10 20 30 40
km
Legend
Ice-Shoved Rampart
Road

Lake Clark National Park and Preserve



Lachbuna Lake



Lachbuna Lake

Lachbuna Lake

Lachbuna Lake

NPS Archeologist Dave Tennessen tested surface soils for artifacts at each site.

Lachbuna Lake

Summary of Radiocarbon Dating of Ice-Shoved Ramparts at Lake Clark NP&P

Lachbuna – 4 ramparts excavated
Telaquana – 2 ramparts excavated

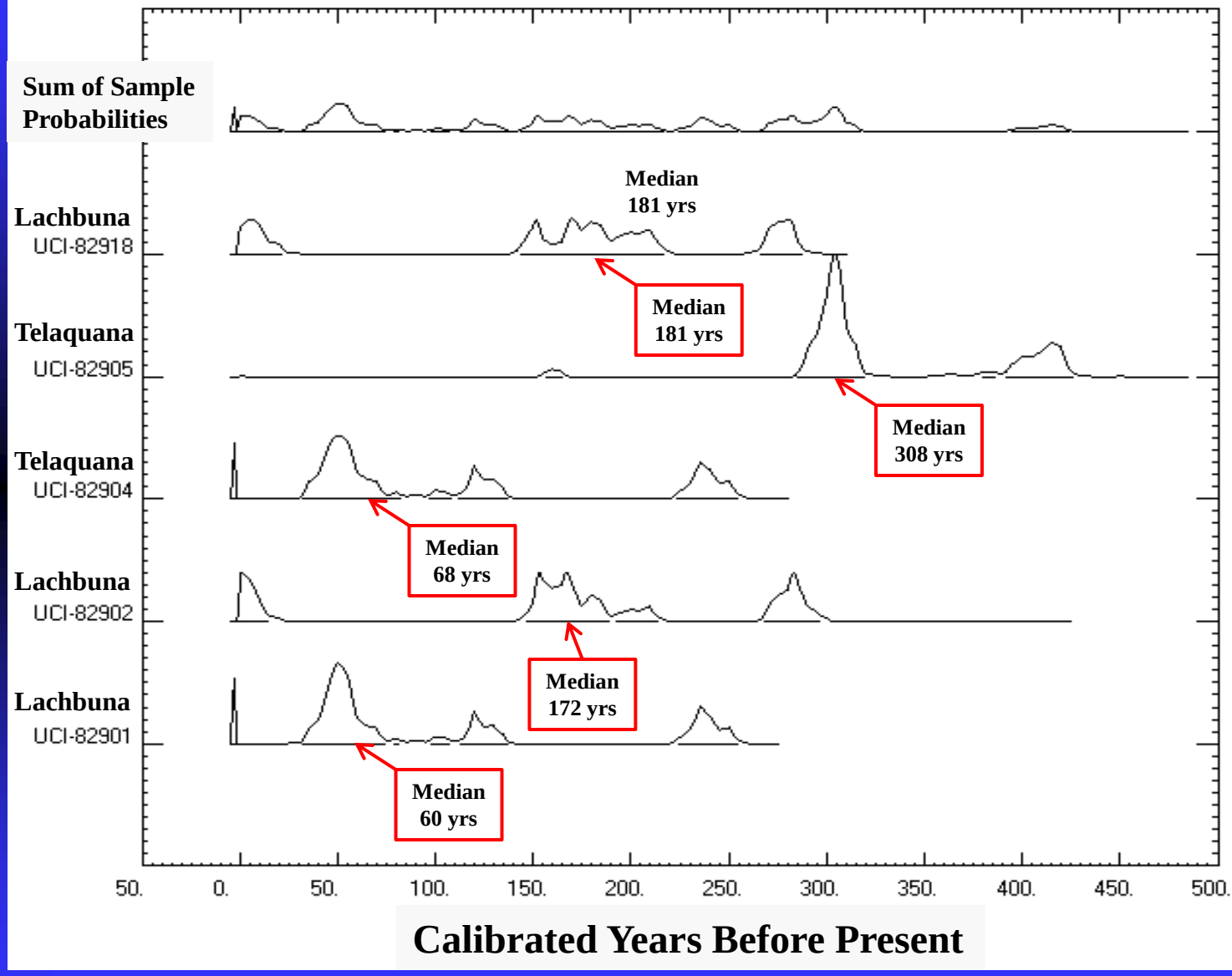
We submitted nine samples for radiocarbon dating.

Four samples returned negative radiocarbon dates, indicating that the samples were "Modern," i.e., contaminated with bomb-generated ^{14}C.

Five samples had dates less than 400 years.

We were surprised that the ramparts are so young, compared to the Kenai where the ages range to 5200 years and even older.

Probability Distributions of Sample Calibrated Ages

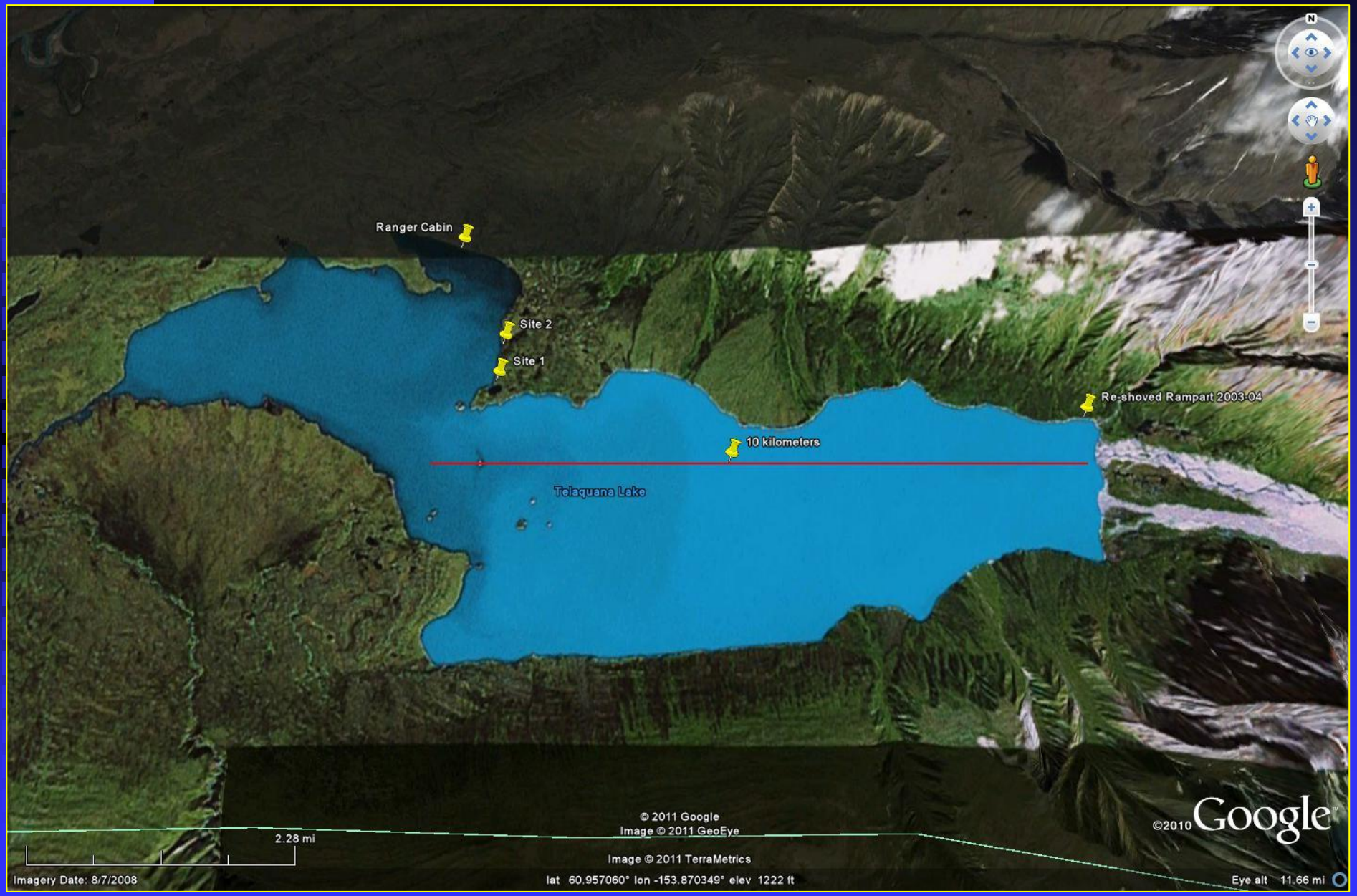


In general, radiocarbon dates less than 400 years old are very dubious.

Paradigm Shift

Our visit to Telaquana Lake provided new insights into the power of expanding ice to form ice-shoved ramparts.

Telaquana Lake – Ice-Shoved Rampart Sites



Jerry and Jeanette Mills
Telaquana Lake 2010

Dick Reger and Ed Berg
Telaquana Lake ice-shoved rampart

Photo by Jeanette Mills

Telaquana Lake – East End
A nearby inholder reported that this rampart was pushed back several feet by ice during the winter of 2003-04, prior to break-up.

Telaquana Lake – East End
Berm and trees pushed by ice in 2003-04.

Telaquana Lake – East End
Berm and trees pushed by ice in 2003-04.

Telaquana Lake – East End
New berm formed after the 2003-04 shove event

Ice-Shoving during the Winter

Lower Twin Lake snow course survey

March 10, 2004

Photos by Buck Mangipane & Leon Alsworth

Lower Twin Lake – South Shore
March 10, 2004

Photo: Buck Mangipane & Leon Alsworth

Lower Twin Lake – South Shore
March 10, 2004

Photo: Buck Mangipane & Leon Alsworth

Lower Twin Lake – South Shore
March 10, 2004

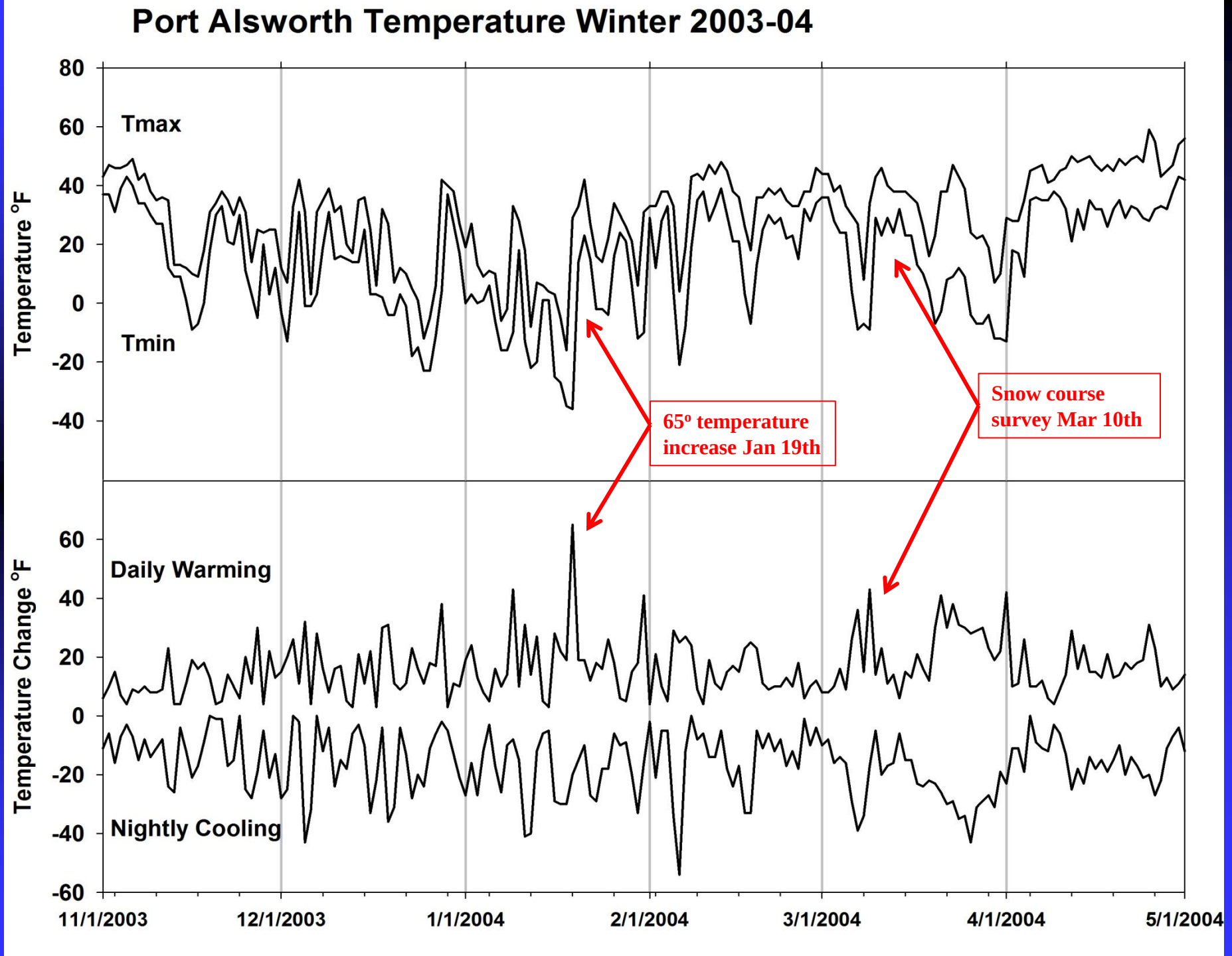
Photo: Buck Mangipane & Leon Alsworth

Lower Twin Lake – South Shore
March 10, 2004

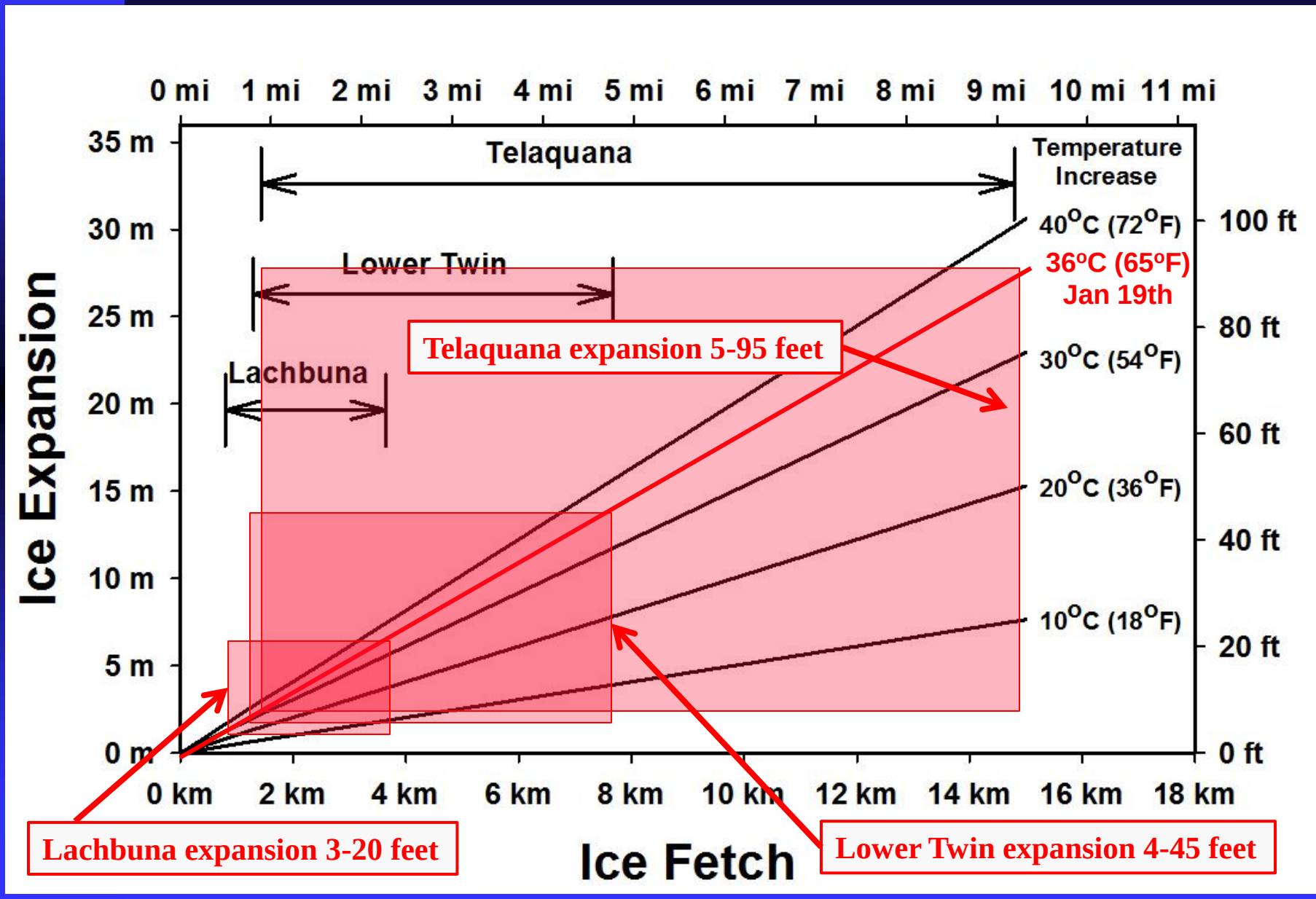
Photo: Buck Mangipane & Leon Alsworth

Conditions Necessary for Ice-Expansion Ramparts (Hobbes 1911)

- Rapid alteration of air temperatures
- Effective communication of these temperature changes to the ice (thin snow cover)
- The lake ice is like a girder: it must be competent to transmit the stresses to the shore
- For large effects, the alternations of temperature must be several times repeated (a ratchet effect)


Port Alsworth Temperature Winter 2003-04
Temperature °F
80
60
40
20
0
-20
-40
Tmax
Tmin
65º temperature increase Jan 19th
Snow course survey Mar 10th
Temperature Change °F
60
40
20
0
-20
-40
-60
Daily Warming
Nightly Cooling
11/1/2003
12/1/2003
1/1/2004
2/1/2004
3/1/2004
4/1/2004
5/1/2004

Theoretical Expansion of Lake Ice with Temperature



From the Literature:

- Ice-expansion ramparts are uncommon on Canadian lakes due to snow cover.
- Ice-expansion ramparts are typically found on lakes or bays less than 1.5- 2 miles in size.
- Ice-raft ramparts are typical in northern lakes, and can be found on some very large lakes.

In Conclusion

- Lachbuna and Telaquana ramparts were probably formed by ice expansion.
- Kenai ramparts show both ice expansion and ice rafting mechanisms.
- It is a puzzle why most Kenai ramparts date to within the last ~5000 years.
- It is a puzzle why Lachbuna and Telaquana show only very young ramparts (<400 years old).